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Full Length Research Paper

Field Evaluation of Commercial Neem Oil in managing Insect Damage on Cowpea in the Forest Zone of Ghana

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Abstract

Over-reliance on synthetic insecticides by Ghanaian farmers to manage cowpea insects has created health and environmental problems. The awareness of these has renewed investigations into the use of biopesticides as alternatives to synthetic chemicals. Field study was set up in a randomized complete block design (RCBD) to compare the efficacy of 3ml/L Karate with three concentrations of commercial neem oil (1ml/L, 3ml/L, 5ml/L) in the forest-transition agroecology. Four replications were used. Aphid infestation was observed on 20% plant population of one plot and was controlled with 3ml/L neem oil. No significant (P>0.05) difference was observed between the efficacy of 5ml/L neem oil and Karate treatments on populations of insect feeding guilds at all stages of crop growth. The application of 5ml/L neem oil was as effective (P>0.05) as Karate insecticide in reducing *Maruca* pod damage. Similar observations were made on the pod damage by pod-sucking bugs complex. Mean grain yield from Karate-treated plots was statistically similar (P>0.05) to the yield from 5ml/L neem-treated plots. Therefore the application of neem oil at 5ml/L can be an effective alternative approach to control cowpea insects.

Key words: Evaluation, neem oil, management, insect damage, cowpea

Introduction

Cowpea (*Vignaunguiculata*(L.)Walp) is a grain legume crop grown mainly in the savanna regions of the tropics and subtropics in Africa, Asia, and South America. It is an important grain legume in the diet of many people in the third world countries as it provides not only high quality protein (25.4%) but also constitutes the cheapest source of dietary protein for low income sectors of the population (Rachie and Singh, 1985; Stanton, 1996). Being a major source of dietary protein, it helps to nutritionally complement the staple low-protein cereals and tuber crops (Stanton, 1996). Besides being low in fat and high in fibre, the protein in cowpea has been shown to reduce low-density lipoproteins that are implicated in heart diseases (Phillips *et al.*, 2003).

Protein isolated from cowpea grains has good functional properties, including solubility, emulsifying and foaming activities (Rangel *et al.*, 2004). It is also a good source of carbohydrate (56.8%), calcium, iron, vitamin B and carotene. Hall *et al.*(2003) emphasized that cowpea seed is also a rich source of minerals and vitamins. Although it is cultivated primarily for its edible seeds, direct consumption of cowpea leaves is also widespread in Africa (Nelson*et al.*, 1997). In its fresh form, the young leaves, immature pods and peas are used as vegetables, while snacks and main meal dishes are prepared from the dried grain (Nelson *et al.*, 1997).

Besides its usefulness in human diet, it serves as an important fodder for feeding livestock. The foliage is an important source of high quality hay for livestock feed (Tarawali*et al.*, 2002). The haulm, which contains about 20% protein, is a highly valued feed and is sold for almost the same price as cowpea grain on dry weight basis (IITA, 1997).Cowpea promotes crop-livestock integration, which leads to better nutrient cycling and enhanced income generation (Alghali, 1993).

Although cowpea possesses an inherently high grain yield potentials ranging from 1.5 to 3.0 t/ha (Alghali, 1993), the actual yields realized from the traditional cropping systems in Africa are consistently low, about 50 to 350 kg/ha (Mortimore *et al.*, 2006; Emechebe and Singh, 1997). Several biological and edaphic as well as socio-economic factors limit the production of cowpea in large quantities in most production areas. According to Singh and van Emden (1979), insect damage is the number one constraint for cowpea production in most production areas in Africa.The socio-economic factors such as farmers' capabilities to procure inputs are limited and also the input delivery systems function poorly. Seed of improved varieties are not easily obtained. The socio-cultural factors which limit the production of the crop include the low acceptability of new cowpea varieties which have the potential of high grain yield production, low adoption of some improved post-harvest technologies and change in taste and urbanization which have favoured the importation of food to the neglect of production and consumption of indigenous food crops such as cowpea.

Of the biological factors which affect cowpea production, insect pests and the damage they cause to the cowpea crop are the most importantconstraints to the crop being produced in large quantities in the producing regions of Africa (Singh and van Emden, 1979). The insect pests are classified into three feeding guilds as pre-flowering (vegetative) insects, flowering (reproductive) insects, and post-flowering (podding) insects. The crop is severely attacked at every stage of crop growth by these insects. The flowering and the post-flowering insects are the most damaging (Olatuade*et al.*, 1991; Alghali, 1993).

The damage caused by these insects can be as high as 80-100%, if not effectively controlled with insecticides (Jackai and Daoust, 1986; Childers and Achor, 1995; Tanzubil, 2000). Various workers have reported that losses in cowpea grain yield due to insect pests vary from 20% to almost complete crop failure (Singh and Allen, 1980; Singh *et al.*, 1985;Jackai and Daoust, 1986; Alghali, 1992; Tanzubil, 2000; Childers and Achor, 1995; Ohno and Alam, 1989; Ogunwolu, 1990). Singh *et al.*(1985) reported that the yield losses caused by the pod sucking insects vary from 30-70% but sometimes could be as high as 90%. Alghali (1992) also reported that in Nigeria, yield loss was up to 75% when insects attacked the crop during the flower budding and flowering stages of the crop. Studies by Tanzubil (2000) concluded that in Northern Ghana, complete crop failure often results when improved cowpea varieties are grown without insecticide sprays.

Most of the insect control measures on cowpea have centred primary on the use of synthetic insecticides (Echendu, 1991). Among the synthetic insecticides which had been recommended for use on cowpeas against insects at various times were Azodrin, monocrotophos, thiodandursban, dimethoate and some pyrethroids such as cypermethrin, cymbush, Karate (Lambda-cyhalothrin). The use of these insecticides has been noted to increase cowpea yields tremendously but complete crop failure had often resulted without the use of these chemicals for protection against the insect pests (Tanzubil, 2000). However, the indiscriminate use of these insecticides has led to accidental poisoning among applicators and consumers, the development of insect resistance, environmental and other health hazards. These observations have long prompted the search for control tactics other than the use of synthetic insecticides (Jackai, 1993; Schmutterer, 1995; Gaby, 2000; Oparaeke, 2004; Obeng-Ofori, 2007; Egho, 2011; Anis, *et al.*, 2012; Degri*et al.*, 2012; Ogah, 2013).

Neem extracts are noted to possess broad spectrum insecticidal properties against insect pests of vegetables, food crops, fruit and other tree crops (Saxena, 1989; Schmutterer, 1995). The use of neem extracts in the management of insect pests of crops has been well documented (Gaby, 2000; Oparaeke, 2004, 2007; Ogah*et al.*, 2011; Ogah, 2013). The neem products and other plant extracts are cost effective crop protectants alternative to synthetic insecticides which are expensive to farmers and detrimental to the ecosystems.

This study was undertaken to assess the biological effectiveness of neem oil, marketed as Grow Safe, in comparison with Karate (Lambda-cyhalothrin), the conventional synthetic insecticide currently used by farmers to control insect pests of cowpea and the damage they cause to the cowpea crop in Ghana.

Materials and Method

The study was conducted at the Sunyani Technical University (formerly Sunyani Polytechnic) Farming Village at DuayawNkwanta in the BrongAhafo region of Ghana to assess the efficacy of commercial neem oil (Grow Safe) against Karate (Lambda-cyhalothrin) in managing insect pests and damage on Asontem cowpea variety.

DuayawNkwanta lies in the moist, semi-deciduous forest zone of Ghana. It lies between longitude 7^{o}00' and 7^{o}25' N and latitude 1^{o}45' and 2^{o}15' W. The mean annual rainfall is between 1,250 and 1,800 mm. DuayawNkwanta experiences double rainfall patterns designated as major and minor seasons. The major season is usually between March and June with June being the peak period. The minor season begins from August and ends in November. The dry season occurs from November to February (MOFA, 2016). The soils consist basically of forest ochrosols with intermediate water retention capacity. Generally, the various types of soil are fertile. The abundant arable land found in the area is suitable for the cultivation of a wide range of food and cash crops (MOFA, 2016).

Experimental design

The field study was organized in a randomized complete block design (RCBD) with five insecticide treatments and four replicates (blocks). Each replicate consisted of five plots which were separated by 1.0 m wide path and the replicates were separated by 2.0m wide. In all, 20 plots were laid out and each plot measured 3m x 2m.

Land preparation and planting

A land area of 252 m^2 was ploughed on April 02, 2016 and harrowed on April 09, 2016. Three days later, the land was lined and pegged into 20 plots as outlined in the experimental design.

Asontem variety of cowpea obtained from the Crops Research Institute of the Council for Scientific and Industrial Research (CSIR) at Fumesua, Kumasi was planted on April 16, 2016. Three seeds were sown per hill at a depth of about 4 cm and covered with a very light soil. The seedlings were thinned to two seedlings per hill 14 days after planting. The planting distance used was 60 cm between rows and 20 cm within rows. Each plot contained four rows and 15 cowpea plant stands per row giving a total of 30 plants per row.

Cultural practices

Gap filling of the plant stands was carried out eight days after planting to ensure that there was an equal number of seedlings on each plot. Cowpea, being a drought resistant crop does not need too much water. However, due to erratic rainfall during the cropping season, there were times/periods that supplementary irrigation was carried out twice a week using watering cans. Weeds were controlled manually with a local hoe. The first weed control was done 14 days after planting and it was repeated three times before harvesting. Compound fertilizer (NPK 15-15-15) was incorporated into the soil,as a basal application at planting,at a rate of 100kgha^{-1}(2 x 50 bagsha^{-1}) for seedlings establishment and plant growth.

Insecticide treatments and application

The insecticide treatments used for the study were 3ml/L of Karate 2.5% emulsifiable concentrate; this insecticide was purchased from local Agrochemicals dealer. The commercial neem oil was prepared in three spray concentrations as 1ml/L, 3ml/L and 5ml/L. The neem oil was procured from Dizengoff Ghana Limited, Accra. For each of the neem oil spray solution, 1.5ml of commercially prepared soap (purchased together with the neem oil) was added to it to enable the neem oil to stick to the foliage of the plants when applied. A control treatment (i.e. no insecticide) was included as a check.

Four spray applications were carried out; two at the reproductive (flowering) stage and two at the post-reproductive (podding) stage of the crop growth. The first spray application was carried out at about 46 days after planting and when 50% of the cowpea plants had formed flowers, it was repeated at 7 days interval. The second batch of the spray application was undertaken when 50% of the pods were formed and was repeated after 7 days. Two separate 15-litre knapsack sprayers were used for the application of the Karate spray solution and neem oil spray solutions. All spray applications were carried out in the evening between 17 hours and 18 hours GMT.

Data collection

A quadrat of 2.4 m^2 comprising 20 cowpea stands (40 plants) was measured out and used for data collection.
The data collected were the insect populations at the vegetative phase (aphids), at the reproductive phase (the number of cowpea flower thrips per flower, sample population of pod borer), and at the post-reproductive phase (i.e. sample population of pod-sucking bugs complex). Other data were pod damage, seed damage, number of pods per plant, number of seeds per pod, seed grain yield, shelling percentage and hull weight.

Assessment of insect numbers

The infestation of aphid was determined by counting the number of plant stands infested with aphid colonies.The cowpea flower thrips, *Megalurothripssjostedti* was assessed by plucking 10 flowers at random from the cowpea stands just outside the quadrat of each plot. The flowers were kept in 250 ml Kilner jars containing 10% alcohol and taken to the laboratory. The number of thrips was counted with the aid of a magnifying glass and the mean computed for each treatment plot.

The assessment of the number of legume pod borer,*Marucavitrata*, was made by taking 10 flowers at random from cowpea stands outside the quadrat of each plot. The flowers were kept in labelled 250 ml Kilner jars and taken to the laboratory for examination. Each flower was carefully opened and visually examined and the number of Maruca larvae recorded. All the flower examination was done early in the morning, starting from 48 days after planting (DAP). Four observations were made.

The population of the pod-sucking bugs complex was assessed in the quadrat of each treatment plot by visually counting all the bugs which were found on the plants within the quadrat on weekly basis. Four assessments were made starting from 49 DAP and ended at 70 DAP. All counts were made between07.00 hours and 08.00 hours GMT and the mean for each treatment was recorded.

Insect damage

Percent pod damage by Maruca pod borer was assessed at maturity after the pods had been harvested. Pods harvested from each quadrat were packed into labelled polythene bags and carried to the laboratory for assessment. Pods were sun-dried for 7 days. The total number of pods harvested from each quadrat was counted. Pods with exit holes were selected and counted as damage by Maruca pod borer. Per centMaruca pod damage was then calculated as ratio of number of pods with holes to the total number of pods per quadrat.

After the pods had been harvested and sun-dried for 7 days, the pods from each quadrat were also assessed for pod-sucking bug damage. Pods showing feeding punctures and unfilled pods were counted as damage by pod-sucking bugs. Percent damage was computed as the ratio of the number of pods with feeding punctures to the total number of the harvested pods in a qudrat.

Seed damage due to pod-sucking bugs complex was assessed by selecting twenty (20) pods at random from each quadrat and threshed manually. The seeds were then counted. Wrinkled seeds and seeds with feeding lesions were counted out of the total as damage by the sucking bugs. Percent seed damage was similarly calculated as the ratio of seed damage to the total number of seeds obtained from the 20 pods.

Yield components and gram yield (tons/ha)

The yield components assessed were the number of pods per plant, the number of seeds per pod, shelling percentage, and hull weight. The number of pods per plant was assessed from the quadrat of each experimental plot. All cowpea pods within the quadrat of 2.4 m^2were harvested and counted. The number of pods per plant was calculated as the ratio of the number of pods within the quadrat to the number of plants harvested.

The number of seeds per pod was assessed when the plants within the quadrat had been harvested 80 DAP. The pods were placed in polythene bags labelled according to the plots. The pods were sun-dried for 7 days and 20 pods were randomly selected from each polythene bag. The selected pods were manually threshed and the seed grains counted. The mean for each plot was then calculated as the number of seeds per pod.

The shelling percentage was calculated as the ratio of the weight of seed grains from the harvested pods within the quadrat of each plot to the weight of the unshelled pods harvested from the quadrat of each plot.

The hull weight was calculated as the difference in weight between the unshelled pods and the seed grains in the pods harvested within the quadrat of each plot. The grain yield was obtained by shelling all the harvested pods within the quadrat of each experimental plot. The seed grains were weighed with an electronic balance and recorded for each experimental plot. The weight of seed grain from each plot was then used to compute the seed grain yield as the metric tonne per hectare (ton/ha).

Results

Insect numbers

Throughout the growth of the crop, aphids, *Aphis craccivora*, infestation was not widely observed. Infestation was observed only on a particular experimental plot where about 20% of the plant population was seen to have been infested. The commercial neem oil applied at a concentration of 3ml/L was able to control the insects completely without any further infestation.

Table 1 presents the efficacy of the commercial neem oil and Karate on the population of the cowpea flower thrips, *Megalurothripssjostedti* on the Asontem cowpea. The analysis of the data showed significant (P<0.05) differences between insecticide treatment at all the stages of the crop growth (45 to 66 days). Plants on plots sprayed with insecticides showed residual population of *M.sjostedti*per flower when compared with plants on the unsprayed (control) plots.

Table 1: The population of cowpea flower thrips,*Megalurothripssjostedti*per flowers of the Asontem variety during 2016 major cropping season*

Insecticide treatment	Days after planting			
	45	52	59	66
Control	7.0^{a}	9.8^{a}	6.9^{a}	4.8^{a}
1ml/L Neem oil	4.3^{a}	9.3^{a}	4.1^{b}	5.4^{a}
3ml/L Neem oil	2.8^{ab}	6.3^{a}	2.4^{bc}	3.0^{b}
5ml/L Neem oil	1.2^{b}	3.8^{bc}	1.6^{c}	1.2^{c}
3ml/L Karate	1.3^{b}	3.0^{c}	1.4^{c}	0.3^{c}

*Mean values in the column followed by the same letter are not significantly different at 5% level of probability.

Throughout the period of the crop growth, no significant (P>0.05) differences were observed between the 5ml/L neem oil and the Karate treatments in reducing the *M.sjostedti* numbers per flower. Again, 5ml/L neem and 3ml/L neem oil treatments were equally (P>0.05) effective in reducing the population of flower thrips except at 66 DAP. The 1ml/L neem oil treatment was not consistently effective during the period of the crop growth. It was also noticed that as the number of days of crop growth increased (from 45 days to 66 days), the number of *M.sjostedti* per flower reduced.

Table 2: The population of legume pod borer, *Marucavitrata* on the Asontem cowpea during 2016 major cropping season*

Insecticide treatment	Days after planting			
	45	52	59	66
Control	3.0^{a}	2.8^{a}	4.5^{a}	3.0^{a}
1ml/L Neem oil	2.3^{ab}	1.8^{ab}	2.8^{ab}	3.0^{a}
3ml/L Neem oil	1.3^{ab}	1.8^{ab}	2.5^{ab}	2.0^{a}
5ml/L Neem oil	0.8^{b}	1.3^{ab}	1.3^{b}	0.8^{b}
3ml/L Karate	1.3^{ab}	1.0^{b}	0.8^{b}	0.5^{b}

*Mean values in the column followed by the same letter are not significantly different at 5% probability level.

The efficacy of the commercial neem oil and the Karate on the population of the legume pod borer, *Marucavitrata* on the Asontem cowpea variety is shown in Table 2. The general observation was that the commercial neem oil at

5ml/L and the Karate at 3ml/L provided better (P<0.05) protection against *M. vitrata* infestation than the other insecticide treatments and the control.

At 45 DAP, neem oil at 5ml/L significantly (P<0.05) reduced the population of *M.vitrata* than the plots which were not sprayed. However, no significant (P>0.05) reduction in pod borer population was observed between neem oil at 5ml/L treatment and the other insecticide treatments (Table 2). Similar observations were made at 52 DAP. At 66 DAP, neem oil at 5ml/L and the Karate treatments significantly (P<0.05) reduced the pod borer population than the other insecticide treatments.

Table 3: The mean population of pod-sucking bugs complex on Asontem cultivar of cowpea during 2016 major cropping season*

Insecticide treatment	Days after planting			
	49	56	63	70
Control	11.3^{a}	7.3^{a}	8.3^{a}	7.5^{a}
1ml/L Neem oil	9.5^{a}	8.3^{a}	6.8^{ab}	6.8^{a}
3ml/L Neem oil	6.0^{b}	4.5^{b}	7.3^{ab}	5.0^{ab}
5ml/L Neem oil	2.8^{c}	2.3^{b}	5.0^{b}	2.3^{c}
3ml/L Karate	1.8^{c}	3.0^{b}	4.8^{b}	1.8^{c}

*Mean values in the column followed by the same letter are not significantly different at 5% probability level.

Table 3 indicates the efficacy of the commercial neem oil and Karate on the population of the pod-sucking bugs complex on the Asontem cowpea. The data from the field trial showed that plants on all plots protected with the insecticides generally reduced the population of the pod-sucking bugs complex when compared with plants on control plots. At all the days of the crop growth except at 63 DAP, there were significant (P<0.05) differences between the insecticide treatments. Generally, the application of neem oil at the concentration of 5ml/L was as effective (P>0.05) as Karate at 3ml/L in reducing the population of the pod-sucking bugs during the crop growth.

Insect damage

The insect damage caused to plant parts is shown in Table 4.

Table 4: Insect damage on cowpea (variety Asontem) during 2016 major cropping season *

Insecticide treatment	% pod damage due to pod borers	% pod damage by pod-sucking bugs	% seed damage by pod-sucking bugs
Control	37.0^{a}	31.2^{a}	30.1^{a}
1ml/L Neem oil	23.0^{b}	25.9^{a}	21.8^{b}
3ml/L Neem oil	19.0^{b}	11.5^{b}	15.2^{b}
5ml/L Neem oil	6.9^{c}	7.7^{b}	6.9^{c}
3ml/L Karate	5.5^{c}	9.1^{b}	7.4^{c}

*Mean values in the column followed by the same letter are not significantly different at 5% probability level

Against damage by *M. vitrata*, plants on plots treated with the insecticides were significantly (P<0.05) better protected than plants on control plots (Table 4). Neem oil at 5ml/L and Karate at 3ml/L were significantly (P<0.05) more effective than the neem oil at 3ml/L and 1ml/L in protecting the cowpea against *M. vitrata* damage. Similar observations were made on damage caused by the pod-sucking bugs complex (Table 4) on the cowpea.

Yield components and grain yield

The components of yield and seed grain yield are presented in Table 5.The number of pods produced per cowpea plant in the neem-protected plots (concentration of 1 – 5ml/L) and Karate were significantly (P<0.05) higher in the number of pods when compared with the pods harvested from the unprotected (control) plots. The number of pods per plant harvested from the plots treated with 1ml/L and 3ml/L neem concentrations, though significantly (P<0.05) lower than the number of pods harvested from plots treated with 5ml/L neem oil, the two lower neem oil concentrations did not differ on the number of pods per plant (Table 5). Plants on Karate-treated plots produced the highest number of pods per plant (13.1) but the observation was not significantly (P<0.05) different from plots treated with 5ml/L neem oil (13.0).

Table 5: Yield components and grain yield of Asontem cowpea variety sprayed with neem oil and Karate insecticides during 2016 major cropping season*

Insecticide treatment	No. of pods per plant	No. of seeds per pods	Hull weight (kg)	Shelling percentage	Grain yield (ton/ha)
Control	5.4[c]	10.8[a]	0.1[b]	68.2[a]	1.3[b]
1ml/L Neem oil	7.3[b]	11.7[a]	0.2[b]	69.8[a]	1.5[b]
3ml/L Neem oil	7.7[b]	11.7[a]	0.2[b]	65.0[a]	1.6[b]
5ml/L Neem oil	13.0[a]	13.2[a]	0.3[a]	68.6[a]	2.9[a]
3ml/L Karate	13.1[a]	12.7[a]	0.3[a]	69.2[a]	3.0[a]

*Means values in the column followed by the same letter are not significantly different at 5% probability

The number of seeds produced per pod did not differ significantly (P>0.05) between the plants which received various treatments. Plants on plots treated with 5 ml/L concentration of neem oil produced the highest number of seeds per pod (13.2) and the lowest was obtained from the control plots (Table 5).

The hull weight recorded from the neem oil applied at relatively lower concentrations (1ml/L and 3ml/L) were not significantly (P>0.05) different from the control plot. However, the hull weight recorded from the neem oil applied at 5ml/L and Karate-treated plots were significantly (P<0.05) different from hull weight recorded from the control and lower concentrations of neem oil (1ml/L and 3ml/L). The higher hull weight produced by plants sprayed with 5 ml/L neem oil and Karate is probably due to the higher number of pods produced by plants on those plots.

No significant (P>0.05) differences were observed between plants which received the various insecticide treatments but generally plants sprayed with 1ml/L neem oil produced the highest shelling percentage (69.8) followed byKarate and 3ml/L neem oil being the lowest. The result shows that the shelling percentage was not dependent on any insecticide treatment (Table 5).

The grain yield (ton/ha) obtained from plants which received 5ml/L of neem oil and 3ml/L of Karate produced significantly (P<0.05) higher yield when compared to the plants treated with the lower concentrations (1ml/L and 3ml/L) of neem oil and the control plots. Relatively lower concentrations of neem oil, however, did not significantly (P>0.05) increase grain yield (1.5 t/ha, 1.6 t/ha) when compared to the control plots (1.3 t/ha) (Table 5). The study showed that though Karate-treated plots produced the highest grain yield (3.0 t/ha), it was not significantly (P>0.05) different in potency against cowpea insect pests when compared to the plots treated with 5ml/L neem oil (2.9 t/ha).

Discussion

The infestation of the cowpea aphid, *Aphiscraccivora* was not extensive on the plots. This observation is probably due to the fact that the study area is not known for extensive cultivation of cowpea. Again, *A.craccivora* infestation is known to be minimal during the major cropping seasons and this general trend has been reported by Egho (2011) and the aphid infestation was effectively controlled by the application of neem oil at low concentration which is in agreement with the observation made by Ulrichs*et al.* (2001).

The analysis of the data shows that the higher the concentration of the neem oil, the better is its effectiveness in controlling the cowpea flower thrips, *Megalurothripssjostedti* (Table 1). This observation is in line with that of Panwhar (2002) who reported that good aqueous solution of neem controlled *M. sjostedti* on cowpea. There was no significant (P>0.05) difference in the effectiveness betweenKarate (3ml/L) and neem oil at 5ml/L. This observation is an indication that neem seed extract can equally reduce the population of *M.sjostedti* to tolerable levels as reported by Ogah (2013). It was also observed that as the number of days for thecrop growth increased (45 to 66 DAP), the number of *M.sjostedti* per flower reduced. This was probably because at 66 DAP, there was less number of flowers being produced by the crop, thus contributing to the reduction of *M.sjostedti* on the crop.

Grigolli*et al.* (2015) had reported that the legume pod borer,*Marucavitrata* has a typical feeding habit which protects the insect pest from adverse factors including insecticides. At 59 and 66 DAP, plants on plots protected with insecticides had reducednumbers of *M.vitrata* when compared with plants in control plots. There was significant (P<0.05) difference between plants sprayed with lower concentrations of neem oil (1 ml/L and 3 ml/L) and the plants on the control plots (Table 2). This observation indicates that though the use of synthetic insecticide is the best control measure (Jackai, 1993), neem oil is equally effective against infestation by *M.vitrata* (Ogah, 2013; Dzemo*et al.*, 2010).

It was observed in this current study that the performance of neem oil on pod-sucking bugs is dose dependent (Table 3). Higher doses of neem oil comparatively resulted in better control (Table 3). The application of Karate, generally reduced the populations of the pod-sucking bugs complex more than the application of all doses of neem oil against the pod-sucking bugs complex. This finding agrees with that made by Jackai (1993) that the use of synthetic insecticide is a better control tactic. However, the commercial neem oil at 5 ml/L could be a suitable alternative to Karate.

Generally, all cowpea plants on plots treated with insecticides significantly (P<0.05) produced pods with reduced damage due to *M. vitrata* when compared with pods harvested from the control plots (Table 4). Karate was more effective in reducing*Maruca* damage (5.5%) in comparison with the neem oil treatments, though the difference was not significant (P>0.05) from the 5ml/L concentration of neem oil (6.9%). The pod damage by *M. vitrata* in the control plot was significantly higher than any pod damage observed in the insecticide-treated plots. This observation agrees with the findings made by Ogunwolu (1990) that pod damage by *M. vitrata* is relatively high when cowpea crop is not protected with any insecticide. Patel and Singh (1997) indicated that pod damage by *M.vitrata* varies from 25 to 40%. The relatively low level of pod damage observed on the 5ml/L neem-treated plots (6.9%) in this study shows the effectiveness of the neem oil at the concentration used. Dzemo*et al.* (2010) and Ogah (2013) had earlier reported that the application of neem reduced pod damage due to *M.vitrata*. The effectiveness of neem oil at 5ml/L being similar to that of Karate at the concentration of 3ml/L, could conveniently replace the synthetic insecticides to control pod damage due to *M.vitrata*.

The analysis of the data showed that plants on plots sprayed with 3 ml/L and 5 ml/L of commercial neem oil as well as the Karate insecticide significantly (P<0.05) protected pods against pod-sucking bugs than the plants on plots treated with 1ml/L neem oil and the control. Even though the pod damage by the bugs on the plots treated with 5ml/L neem was relatively the lowest (7.7%), this damage was not significantly (P>0.05) different from the damage observed on the insecticide-treated plots (Table 4). The seed damage on plots sprayed with 5ml/L neem oil (6.9%) was comparatively similar (P>0.05) to the damage observed on plots treated with 3ml/L Karate (7.4%). Mean seed damage by pod-sucking bugs on plots treated with 3ml/L neem oil (15.2%) was significantly (P<0.05) less than mean seed damage on plots without any protection (control) (30.1%).

These observations confirm the findings of Dzemo*et al.*(2010) who had reported the effectiveness of neem against the pod-sucking bugs complex. The potency of the 5 ml/L neem oil in showing relative effectiveness against the pod-sucking bugs complex might be attributed to the anti-feedant nature of the neem (Schmutterer, 1990) and its azadirachtin content which is knownto be lethal to a wide range of insect pests including pod-sucking bugs (Oparaeke, 2007). Similarly, it was reported by Ogah*et al.*(2011) that the very high significant reduction on the incidence of cowpea insect pests observed on plots sprayed with neem oil may be attributed to a combination of many genetic properties of the neem tree that makes it better insecticides in producing than other plants.

Themean number of the harvestable pods per plant was significantly (P<0.05) higher on plots sprayed with Karate, and neem oil at 5ml/L than plots sprayed with neem oil at 3ml/L, 1ml/L and the plants in control plots in that significant (P<0.05) order. These observations in the treatments might be due to higher infestations of the cowpea flower thrips and legume pod borers during the reproductive stage of the crop growth, and thus resulting in substantial loss of flowers. Childers and Achor (1995) have made similar observations. The reduced number of flowersdue to the insects is likely to have resulted to the reduction in the number of harvestable pods in the control plots and plots sprayed with 1ml/L and 3ml/L neem oil. The grain yield realized from the various treatments was the consequences of the pods which were therefore harvested. The grain yield (ton/ha) was significantly (P<0.05) high on plots treated with 5ml/L neem oil and Karate.

Conclusion

Cowpea (*Vignaanguiculata*) farmers in Ghana rely mainly on synthetic insecticides to control insect pests and their damage to the crop. However, the use of synthetic chemicals and the attendant health problems for applicators, consumers and the environment have prompted the use of other control measures as alternatives to synthetic chemicals.

The findings from this study on the use of neem oil have revealed that this biopesticide can be a reliable alternative measure to control insect pests of cowpea, particularly when applied at a relatively higher concentration. The use of this neem oil should therefore be encouraged among subsistence farmers involved in the tropical agriculture.

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